Cyfluthrin criteria derivation

Overview and summary. Cyfluthrin is a synthetic pyrethroid insecticide that is the active ingredient in a number of insecticide products, some of the more common include; Baythroid, Baythroid H, Attatox, Contur, Laser, Responsar, Solfac, Tempo and Tempo H. In addition, this compound is included in other combinatorial pesticide products such as Baythroid TM (with methamidophos) and Aztec (with tebupirimphos). Cyfluthrin is generally considered to be highly toxic to marine and freshwater organisms. This criteria report for Cyfluthrin was generated based upon an updated methodology for deriving freshwater water quality criteria for the protection of aquatic life (TenBrook *et al.* 2009a). Ultimately, there were are a number of assumptions, limitations and uncertainties involved in the criteria derivation of this compound that resulted from a lack of available studies, and these limitations are clearly identified in the document. Clearly, the uncertainty surrounding the ecological risk of this compound could be reduced by additional studies in several key areas, including the addition of acute and chronic data sets for relevant aquatic species, and the role of modifying factors such as temperature, pH and partitioning on aquatic organism toxicity.

Comments:

Physicochemical data. Presentation of physicochemical data for this compound is somewhat complicated by the fact that it consists of several steroisomers. However, the authors present an appropriate summary of physicochemical information that takes into consideration these factors.

Information availability. Bioconcentration factors were only available for two species, including bluegill sunfish and Daphnia. Rather limited dietary information was available regarding humans and wildlife for those species with significant dietary sources in water. Specifically, there was some limited dietary information available for Mallard ducks only. These data gaps did not appear to significantly hamper the derivation of criteria for this compound relative to some other factors listed below.

Collectively, the authors identified and reviewed 53 studies. Where applicable, the report includes justification for the reduction of scientific data used to establish the water quality criteria. The data reduction approaches used in the criteria derivation document were described in the 2009 methodology. As with the other compounds reviewed in this series, a host of parameters were rated for data acceptability including, organism source and care, control description and response, chemical purity, concentrations tested, water quality conditions, and statistical methods. Single-species effects studies that were rated relevant (R) or less relevant (L) based upon the previous methodology of TenBrook *et al.* Ultimately, 16 acute toxicity studies collectively yielding 34 toxicity values, were judged reliable and relevant (RR) for criteria derivation, and 3 chronic toxicity studies were judged reliable and relevant (RR) for criteria derivation. Seven mesocosm, microcosm and ecosystem studies were identified and reviewed. Five of these studies were rated either relevant or less relevant and were used as supporting data in section 13. Collectively, these studies provided a smaller database to derive criteria values then available for some of the more commonly used agricultural compounds.

Comments on the acute and chronic criterion calculations. Because of the lack of available studies, there were not 5 acceptable acute toxicity values available to fulfill the five taxa requirements of the species sensitivity distribution (SSD) procedure described by Tenbrook et al. However, four of five taxa requirements were met, and the missing taxa was an insect. As a result of this data gap, the Assessment Factor (AF) procedure was used to calculate the acute criterion according to the methodology of TenBrook *et al*. This procedure resulted in an acute criterion of 0.2 ng/L. Similarly, chronic toxicity values were not available from 5 different families of aquatic organisms, and thus the acute-to-chronic ratio (ACR) method was used to calculate the chronic criterion. The lack of available toxicity studies is a source of uncertainty surrounding the ecological risk of this compound, especially given that for the chronic toxicity data set, there was no data for benthic organisms, considered sensitive species in these data sets (due to the potential for higher exposures associated with sediment contact). This is pointed out by the authors in their discussion.

Comments concerning sensitive, threatened and endangered species. The authors discuss that several federally listed threatened or endangered species, including rainbow trout, may be relevant to these waters. The acute data set includes a SMAV for rainbow trout of 0.119 μg/L calculated from three studies rated RR. The chronic data set includes a SMAV for remote trout of 0.0133 μg/L calculated from two endpoints in one study rated RR. Both of these values in the data sets were included in the criteria calculations and are well above the recommended criteria. The authors used the USEPA interspecies correlation estimation (ICE) software to estimate toxicity values for the listed animals or plants represented in the acute data set by members of the same family or genus. This was accomplished for other endangered trout. There are no aquatic plants listed as state or federal endangered, threatened or rare species, so they were not considered in this analysis. Based on the available data and estimated values, there was not clear evidence that the calculated acute and chronic criteria would be underprotective of threatened and/or endangered species. This is highlighted by the fact that the chronic criterion of 0.04 ng/L was roughly a factor of >330 below the lowest acceptable chronic value (MATC) of 0.0133 μg/L for rainbow trout. With regards to sensitive species, the lowest acute value in the data sets rated RR, RL, LR, or LL was 1.7 ng/L for *Hyalella azteca*, and the derived acute criterion (0.2 ng/L) is well below all of the acute values in the available data sets, and thus assumed to be protective. Furthermore, the derived chronic criterion (0.04 ng/L) is likely to be protective given that the lowest chronic value (MATC) in the acceptable data sets was 0.27 ng/L for *Mysidopsis bahia* (Hoberg *et al.* 1986).

Water quality and temperature considerations. Increased toxicity of pyrethroids with decreasing temperature has been reported, but it is unclear as to if these effects are real or due to interlaboratory variation. There is limited data of temperature affects on aquatic exposures, and it was not feasible to quantify the relationship between the toxicity of cyfluthrin and temperature for water quality criteria. Most importantly, it was not possible to quantitate the modulation of cyfluthrin toxicity at temperatures below 20 °C, which can occur in some streams in the California Central Valley. The authors propose that for colder water bodies, it may be appropriate to apply an additional safety factor to the cyfluthrin criteria in specific areas. This is a reasonable approach, although more information targeting the effect of temperature on sensitive aquatic species is certainly warranted to reduce the uncertainty surrounding criteria derivation. If future studies become available, it may be possible to incorporate temperature information, as well as data regarding pH or other water quality parameters, into criteria compliance.

Bioavailability. Bioavailability is another source of uncertainty regarding the derivation of criteria compliance for this compound. There is little information available on dietary exposures of pyrethroids to aquatic organisms, except in the case of aquatic insects. In general, the studies indicate that ingestion may be an important exposure route, but there's not enough information to incorporate ingestion exposures into criteria compliance assessment. Although pyrethroids are typically poorly soluble in water, these compounds are considered toxic to aquatic organisms, and toxicity to aquatic organisms from pyrethroid exposures has been reported in the Central Valley. The authors cite a report that suggests that pyrethroid toxicity in the Central Valley waters might be a result of dissolved, as opposed to particulate bound, compound (Amweg *et al.* 2005). If this is the case, then dissolved cyflurthin concentrations may be the best predictor of toxicity. By contrast, the authors cite that equilibrium partitioning models suggest that bioaccumulation of cyfluthrin can lead to *in vivo* desorption and subsequent exposure. In essence, the bioavailability of this compound in aquatic systems appears to be very difficult to predict and has the potential to very markedly among sites. The authors suggest a reasonable approach of using SPME-based studies in specific sites to address these issues. Ultimately, authors make the argument that due to these uncertainties, whole water concentrations should be used for cyfluthrin criteria compliance. This argument appears reasonable given the poor state of the science surrounding the bioavailability of cyfluthrin.

Mixtures. Exposures to cyflurthin has the potential to occur in the context of mixtures with other pyrethroids and chemical synergizers. One study indicated that the toxicity of cyfluthrin alone was less than that in the presence of piperonyl butoxide (PBO) a common additive and synergizer of pyrethroid toxicity. The study was conducted in *D. magna* and no other studies on aquatic organisms were identified that could provide a realistic and quantitative means to consider mixtures of cyfluthrin with other classes of pesticides. Because no multi-species interaction coefficients (K) were available to describe the synergism between cyfluthrin and PBO, it was not possible to account for this interaction in compliance determination. This data gap regarding mixture interactions is not specific to cyflurthin.